Convolutional networks (2020)

Deadline: 30 Oct 23:59

Bonus

The goal of this exercise is to classify handwritten digits from the MNIST database. Instructions for loading the datasets are given the folder "Instructions and Data Loading".

To obtain credits for this exercise, upload a PDF-document presenting your results (details below). Use the upload button at the top of this page. Merge the PDF-files you have uploaded for Homework 3 into one document. Make a front page, and attach the computer code you have used in appendices. Submit your merged PDF-document to URKUND, before the deadline.

In this exercise you are asked to train two different convolutional networks into classifying handwritten digits from the MNIST data set. Comparing with the networks in exercises 1-3, you are expected to get better accuracies for the test set in this exercise.

The follwing instructions are written for MATLAB:s Deep Learning Toolbox, MATLAB data-type and variable names. For details on MATLAB:s toolbox go to Chapter 7 of the lecture notes or to this example from MathWorks. You may implement the networks below in another computer language if you want, but then you need to figure out yourself how to translate the instructions.

Network 1

Construct a convolutional neural network consisting of one convolution layer with 20 feature maps followed by a max-pooling and one fully-connected layer. The precise layout is as follows:

- imageInputLayer
- convolution2dLayer with padding = 1, stride = 1, receptive field of 5×5, and 20 feature maps (followed by reluLayer)
- maxPooling2dLayer with padding = 0, stride = 2, pool-size of 2×2
- fullyConnectedLayer of 100 neurons (followed by reluLayer)
- fullyConnectedLayer of 10 neurons followed by softmaxLayer and classificationLayer

Train the network using stochastic gradient descent with Momentum = 0.9 for at most 60 epochs with MiniBatchSize = 8192

and InitialLearningRate = 0.001. For early stopping use ValidationPatience = 5 and ValidationFrequency = 30. For the convolution layer and fully connected layers, initialise the weights from a normal distribution with mean 0 and standard deviation 0.01 (set the WeightsInitializer argument to narrow-normal). Shuffle the training set before each epoch. Calculate the classification errors obtained on the training, validation, and test sets separately. The training time should be at most 2 hours on one CPU.

Network 2

Network 2 is a deeper convolutional network than Network 1. It consists of three convolution layers with 20, 30, 50 feature maps, respectively. The precise layout is as follows:

● imageInputLayer

● convolution2dLayer with padding = 1, stride = 1, receptive field of area 3×3, and 20 feature maps (followed by batchNormalizationLayer and reluLayer)

● maxPooling2dLayer with padding = 0, stride = 2, pool size of 2×2

● convolution2dLayer with padding = 1, stride = 1, receptive field of area 3×3, and 30 feature maps (followed by batchNormalizationLayer and reluLayer)

● maxPooling2dLayer with padding = 0, stride = 2, pool size of 2×2

● convolution2dLayer with padding = 1, stride = 1, receptive field of area 3×3, and 50 feature maps (followed by batchNormalizationLayer and reluLayer)

● fullyConnectedLayer of 10 neurons followed by softmaxLayer and classificationLayer

Train the network for at most 30 epochs with Momentum = 0.9, MiniBatchSize = 8192 and InitialLearningRate = 0.01. For early stopping use ValidationPatience = 5 and ValidationFrequency = 30. For the convolution layers and fully connected layers, initialise the weights from a normal distribution with mean 0 and standard deviation 0.01 (set the WeightsInitializer argument to narrow-normal). Shuffle the training set before each epoch. Calculate the classification errors obtained on the training, validation, and test sets separately. The training time is expected to be 6 hours or less.

Presentation of results

Upload a one page PDF-document presenting and discussing your results.

Submit at most one A4 page with 12pt single-spaced text, and with 2cm margins. Each page may contain at most one Figure and/or one Table with the corresponding Figure and/or Table caption, in addition to the text discussing the results shown in the

Figure/Table. It is not necessary to write a full page for each of the four problems in homework 3, but you must explain/describe what you have done and clearly state your answers/results to the questions, as well as your conclusions. When necessary you must discuss possible errors and inaccuracies in your results. Plots/graphs must have legible axis labels and tic labels. All symbols and lines must be explained in the Figure or in a caption. The Figure may consist of separate panels, label them 'a', 'b', and so forth).